Raising the Technology Readiness Level of 4.7-THz local oscillators

Completed Technology Project (2016 - 2019)

Project Introduction

The 63-μm (4.744 THz) [OI] fine-structure line is the dominant cooling line of warm, dense, neutral atomic gas. Because of its great intensity in high UV photodissociation regions (PDRs) and shocks, the [OI] 63-μm line is superior in probing regions of massive star formation and the centers of galaxies. It is a unique probe of PDRs, shock waves from stellar winds/jets, supernova explosions, and cloud-cloud collisions. These radiative and mechanical interactions shape the interstellar medium of galaxies and drives galactic evolution. The size scale of the interactions can excite [OI] emission over many parsecs. Moreover, the emission regions are often complex, with multiple energetic sources processing the environment. Spectrally resolved observations of the [OI] line with a heterodyne receiver array will allow users to disentangle this convoluted interaction and permit the study of the energy balance, physical conditions, morphology and dynamics of these extended regions. In this way, such a receiver array will provide new, unique, insights into the interrelationship of stars and gas in a wide range of galactic and extragalactic environments. Despite the great potential, however, astrophysical observation of the OI line has rarely been performed because the frequency (4.744THz) is beyond the reach of most of the implemented local oscillators (LOs) in sensitive heterodyne receivers involving cryogenic mixers. In this proposed 3-year project, we plan to raise the TRL of THz QCLs for local oscillator applications to 5 or beyond, so that we will bridge this "mid-TRL gap" between a promising and enabling technology and a mission-ready component. Such a development will significantly reduce the risk of several proposed suborbital projects such as GUSTO (The Gal/Xgal U/LDB Spectroscopic/Stratospheric THz Observatory) which is a long-duration balloon flight. The proposed systems includes a 9-element heterodyne receiver array for the 4.744-THz OI line. Those heterodyne receiver arrays will require a large LO power level in a good beam pattern. Specifically, by end of the proposed project, we will develop single-mode DFB lasers with frequency to be within 10 GHz of the target 4.744 THz line, cw output power of ~5 mW with a wall-plug power efficiency of ~0.5% at an operating temperature of ~40 K, and beam patterns narrower than 10×10 degrees. This proposed project mainly addresses NASA's Strategic Subgoal 3D, Discover the origin, structure, evolution, and destiny of the universe, and search for Earth-like planets. It also addresses NASA's Strategic Subgoal 3A, Study planet Earth from space to advance scientific understanding and meet societal needs; and NASA's Strategic Subgoal 3C, Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space.

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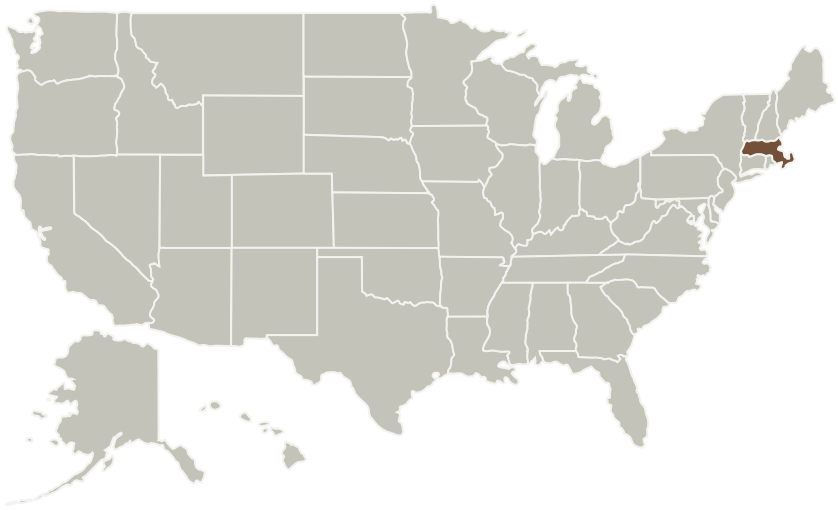
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations
Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Strategic Astrophysics Technology

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

Qing Hu

Co-Investigator:

Michael P Corcoran

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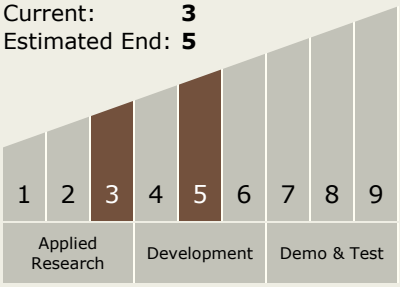
Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System